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IS THERE A SHORTAGE OF COMPUTER PROGRAMMERS/SYSTEMS ANALYSTS? AN EXAMINATION OF THE EMPIRICAL EVIDENCE

by

Steven Schuyler Anderson

September, 1990

Thesis Advisor: William J. Haga

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Is There A Shortage of Computer Programmers/Systems Analysts?
An Examination of the Empirical Evidence

by

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Submitted in partial fulfillment
of the requirements for the degree of

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ABSTRACT

This thesis investigates the alleged shortage of computer programmers and systems analysts. The basic premise of this thesis is to quantify the supply of and the demand for computer specialists to determine whether there is empirical evidence of a shortage. A quantification of the supply of computer specialists is presented. Based on an examination of available literature, there is no quantification information available of the demand for computer specialists.

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I. INTRODUCTION

A. OVERVIEW

There is a widely held belief within the information systems industry that a shortage of computer programmers/system analysts exists. This alleged shortage has also been referred to as "the software crisis" and has been advanced in industry periodicals since the mid 1970's. The "shortage" has become an accepted truism in the current text books dealing with information systems at the graduate education level (Cash, et al, 1988, pp. 253, Leigh and Burgess, pp. 34, 1987).

In 1990 the assistant director for computer and information sciences and engineering at the National Science Foundation, William Wulf, declared that, "If you project current trends in (both commercial and military) software supply and demand out to the year 2040, you find that every man, woman and child in the country will have to be a software programmer" (Kitfield, 1989, pp:27).

In a roundtable discussion on the critical programmer shortage in 1982, Mr Gerald Cohen, President of Information Builders Inc., placed a historical perspective on a similar "shortage."

> Before World War I, the vision of a telephone in every home and office was pooh-poohed by the pundits as being unfeasible, for the entire population of the United States would have to be recruited to switch the calls. Of course, the critical possibility that wasn't taken into account was automation of the process. (Lasden, 1982, pp: 113)

The American Heritage Dictionary of the English Language defines a "crisis" as: "An unstable condition in political, international, or economic affairs in which an abrupt or decisive change is impending." It would seem, based on that definition that it would not be possible to be in a software "crisis" that has lasted over a decade.

B. APPROACH

In order for a shortage to exist, the demand for a good or service must exceed the supply of that good or service at a given price. Certainly, most people would like to own a Mercedes Benz. However, based on the market determined price few people are willing to pay for one. Yet, we don't hear complaints that there is a shortage of luxury automobiles. Shortages can only be understood in terms of price and quantity desired that correspond to the equilibrium intersection of supply and demand curves.

This thesis will attempt to find empirical estimates for the supply and demand of programmers and system/analysts based on a review of the information industry literature, government

statistics and other sources. Based on these estimates, if they exist, the demand will be compared to the supply at appropriate quantities and prices to determine if a shortage does exist and, if so, to approximate its magnitude.

II. METHODOLOGY

The research methodology of this thesis centers around a literature review. A secondary source of material involved conducting verbal interviews with individuals who were mentioned in the literature as having indicated a quantification of the programmer/systems analysts shortage.

The initial literature search was conducted through the Dudley Knox Library, Naval Postgraduate School on 16 July 1990. The DIALOG Information Services Inc, of Palo Alto, California was utilized. Six files were searched by DIALOG: Abi/Inform (Copr. 1990 Uni/Data Courier), Management Contents (Copr. 1990 Information Access Co.), Computer Database (Copr. 1990 Information Access Company), Inspec (Copr. IEE 1990), Compendex Plus (Corp. Engineering Info Inc.), Ntis (Copr. 1990 Ntis).

Key words for the search were: shortage, shortfall, programmer, systems, analyst, systems analyst. The initial search resulted in two hundred and seventy two unique items in the periodical literature. The abstract of every article was reviewed and each article that appeared to provide a source of quantifying either the supply of or demand for programmers was investigated in detail.

A secondary literature search was also conducted at the Dudley Knox Library on 3 August 1990, through the Research Reports and Classified Materials Division. Two hundred and sixty one technical reports and theses were listed as containing elements of the same key words conducted in the DIALOG search. All abstracts were reviewed and those that appeared to be the most promising for offering quantification of the shortage were reviewed in their entirety.

The textbooks that were reviewed for indications of a programmer/systems analyst shortage were limited to the required textbooks for the Computer Systems Management Curriculum at the Naval Postgraduate School. Although the number of textbooks reviewed was limited, the material within the various textbooks was consistent in the lack of quantification.

A search of various computer magazines and journals via the Computer Library CD-ROM program revealed additional articles. Again these articles were reviewed for possible quantification information.

Based on information gained from the literature review, phone interviews were conducted with governmental and private organizations that appeared to have potential for providing information for the quantification of the shortage. Organizations contacted include: The Bureau of Labor Statistics, the Internal Revenue Service, the National Science

Foundation, the Institute of Electrical and Electronic Engineers, Fox Morris Personnel Consultants, The San Francisco Newspapers Advertising department and other sources. The results of these interviews and the literature reviews are detailed in the background, presentation of data collected and data analysis/interpretation sections of the thesis.

III. THE LITERATURE OF PROGRAMMER/SYSTEMS ANALYST SHORTAGE

There have been over 250 articles within the information industry literature over the last ten years that have indicated that there is shortage of computer programmers/system analysts. Some of these articles make reference to a shortage as it affects other aspects of the information industry, while some articles deal with specific causes and possible solutions to the shortage problem. The articles that specifically deal with the shortage can be categorized in the following areas.

A. HOW TO RECRUIT PROGRAMMERS

In order to establish an information staff for an organization, programmers/system analysts must be recruited in a highly competitive environment. "Hiring Wars" have been declared in which organizations offer high salaries and a variety of bonuses to help the programmer to decide where to work. (Raimondi, 1986, pp: 1, Beeler, 1981, pp: 15)

Another consideration is to present a good image to the perspective employee. Organizations using leading edge technology and presenting an image that growth within the organization is possible will maintain an advantage in their ability to recruit a staff. (Howe, 1982, pp: 41-42)

Another proposed solution to the problems involved with recruiting programmers is to recruit prospective programmers from non-traditional information labor sources. Recommended additional labor sources include the handicapped population, minority hiring and recruiting talent from overseas.(Beeler, 1981, pp: 40, Verity, 1981, pp: 82-36)

One article suggests that if programming talent is difficult to recruit, don't. Instead of trying to compete in a highly competitive hiring environment, the use of temporary help from agencies that provide temporary personnel for the information industry, may be an organizations best alternative for developing a particular application or supplement staffs in the short term.(Paznik, 1986, pp: 25-29)

B. HOW TO KEEP THE PROGRAMMERS YOU DO HAVE

These articles address the problem of how to keep the programmers that you have been able to recruit. Solutions that are proposed to organizations include changing policies on nontraditional working schedules and management flexibility as a solution to the shortage (Ruhl, 1990, pp: 111).

Another suggested method for retaining programmers is through growth motivation, by increasing educational opportunities and providing upward mobility for IS professionals (Couger, 1990, pp: 73-76, Howard, 1980, pp: 1-4).

One article concentrated on having experienced employees and supervisors serving as mentors for new programmers. The concept behind this proposal is that a new programmer that is welcomed to the new company and taken care of is likely to develop a loyalty to the organization that will raise job switching costs for the employee.(Nasser, 1989, pp: 99-107)

C. HOW TO GET MORE OUT OF YOUR PROGRAMMERS

One proposed solution to the programmer shortage has been a cry to increase productivity and to reduce the complexity of programming through new techniques so that any traditional user will be able to do their own programming. A variety of vehicles to accomplish this transformation have been proposed. One particular vehicle for achieving this objective is through visual programming, a technique in which a user directs a computer by "showing" it rather than telling it what to do. (MacDonald, 1982, pp: 132-140, Johnson, 1982, pp: 17, Cook, 1981, pp: 1-18, Anonymous, 1981, pp: Special Report 32, Pitagorsky, 1980, pp: 27-31, Emmett, 1982, pp: 70-77, Bosworth, 1983, pp: 139-144, Venkatakrishnan, 1983, pp: 175-180)

D. INCREASING THE SUPPLY OF PROGRAMMERS

A few of the articles chose to investigate what could be done to actually increase the number of programmers that are

available, rather than deal with the short range problems of how to recruit and maintain information professionals. One article urges organizations to spend time supporting educational efforts at high schools and colleges to promote the information professional field (Washington, 1988, pp: 17).

Another article indicated that industry itself was a chief cause of the shortage problem. The logic proposed is that industry has hired the best and brightest graduates and has caused a shortage of qualified teaching staffs, which in turn limits the number of graduates that our educational institutions can process in a given academic year. (Batt, 1981, pp: 14, Decamp, 1980, pp: 44-48)

One article recommends that industry take educational matters into its own hands and begin to train information professionals within the job environment. This recommendation of investing in the education of the work force by industry has some positive merits, such as tailoring the individual's skills for specific organizational needs and at the same time satisfying the educational growth needs that many information professionals exhibit. (Yasaki, 1981, pp: 70-73)

E. SUMMARY OF LITERATURE REVIEW

The industry literature that I have reviewed on the programmer/systems analyst shortage have a few common themes. First, almost without exception, all the articles declared

that a shortage of programmers/systems analysts exists and is serious. Second, only a few articles bothered to make an attempt at quantifying the supply of programmers and the demand for programmers/systems analysts was not quantified at all. The few articles that indirectly probed the demand issues may have touched on the root of the problem.

IV. PRESENTATION OF DATA COLLECTED

As discussed in the literature review section, there was a lack of quantification data present in the literature. What data was available is presented below in chronological order.

A. 1980

In October 1980, the National Science Foundation's "Science and Engineering Education for the 80's and Beyond" projected 550,000 jobs for programmers, systems analysts and other computer professionals would open in the U.S. between 1978 and 1990. The supply of college graduates in those fields would be no more than 157,000 during those same years the report predicted.(Gillin, 1983, pp: 4)

Another source predicted a shortfall of approximately 50,000 programmers for 1981. And went on to postulate that this would naturally lead to a severe shortage of new application software.(Shoor, 1980, pp: 71)

One government report estimated that during the next decade, personnel shortages within the industry as a whole will approach 20% compounded per year. Readings taken throughout the industry by Dunhill/DP (a DP recruiting network in North America) indicated the possibility of a 20% shortfall for systems programmers during 1981 and a 40% shortfall for applications people. A nationwide survey Dunhill conducted in

December 1980 among 20 top metro markets revealed that companies across the board plan to increase their hiring in 1981 by anywhere from 10%-40%. U.S. Department of Labor statistics confirm the serious nature of the shortages. Jobs for computer professionals are expected to increase nearly 84% by 1990, more than four times the projected rate of growth for all occupations in the country.(Decamp, 1980, pp: 44-48)

Speaking at Data Training '80, sponsored by Northeast Training News, Ebert predicted a 40% shortfall of programmers by 1985, even though some 300,000 will be in existence (Howard, 1980, pp: 1-4).

According to the Bureau of Labor Statistics, there are 534,000 programmers and systems analysts in the US, an increase by 25 percent over two years ago (Stibbens, 1980, pp: 74-76).

B. 1981

The U.S. Department of Labor statistics confirms the serious nature of the shortages. Jobs for computer professionals are expected to increase nearly 84% by 1990, more than four times the projected rate of growth for all occupations in the country. One government report estimates that during the next decade, personnel shortages within the industry as a whole will approach 20% compounded per year.

In fact the U.S. Department of Labor predicted a 109% increase in the number of computer professionals employed in this arena over the next decade.(Decamp, 1980, pp: 44)

In 1975, 10% to 15% of the demand for programmers was not met. By 1985, the shortfall of programmers is expected to be 45% to 50% of demand. Even today, the backlog of programming tasks facing the average Fortune 500 company is 2 1/2 years.(Cook, 1981, pp: 1-18)

Computer employee demand rates were recorded at 21.2% in 1979 and 18.7% in 1980. These employee demand figures were derived from surveys conducted by Fox-Morris Personnel Consultants and its National Personnel Consultants affiliates over the last three years.(Dooley, 1981, pp: 1-6)

C. 1982

The Bureau of Labor Statistics predicts that from now until the end of this decade, there will be a continuing shortage of 25,000 computer programmers each year. It also forecasts that by 1990, more than two million people in the U.S. will be working with computers or in computer related jobs.(Scannell, 1982, pp: 9-10)

There's a severe shortage of experienced people. And it's getting worse and will stay that way for some time. Depending on which periodical you read, there's a 50,000 to 100,000 shortfall of programmers.(Lasden, 1982, pp:104-118)

D. 1987

In Japan, software developers are getting more expensive, mainly due to the programmer shortage, which the Ministry of International Trade and Industry estimates will reach 600,000 by the 1990's (Poe, 1987, pp: 30-34).

Based on the references to the National Science Foundation I contacted that agency and obtained from them the 1986 and 1988 editions of "U.S. Scientists and Engineers, Surveys of Science Resources Series, Detailed Statistical Tables. I opine that this is probably the best quantification data available on the supply of "computer scientists". A summary of the survey techniques and results are detailed below.

The National Science Foundation (NSF) has made an estimate of the employment characteristics of the Nation's scientists and engineers in (S/E) 1986 and 1988. The data that the report is based on is gathered in three surveys: The Experienced Sample of Scientists and Engineers, The Survey of National and Social Science and Engineering Graduates and The Survey of Doctorate Recipients. The characteristics of each of these surveys are detailed below.

The Experienced Sample of Scientists and Engineers is the follow up survey series to the 1982 Postcensal Survey of Scientists and Engineers. The Postcensal sample was drawn from respondents to the 1980 decennial census. This survev

measures the magnitude and characteristics of individuals in the S/E population at the time of the 1980 Census. The surveys have been conducted for the NSF by the Bureau of the Census in 1982, 1984, 1986 and 1989.

The Survey of Natural and Social Science and Engineering Graduates is designed to measure the characteristics of those who earned degrees in S/E fields after the 1960 decennial census. The Institute for Survey Research, Temple University, conducted this survey series for NSF in 1982, 1984, 1986 and 1988 and is currently conducting the 1990 survey.

The Survey of Doctorates Recipients focuses on the characteristics of scientists and engineers who have been granted doctorates by U.S. universities and colleges. Since 1973, this survey series has been conducted on a biennial basis for NSF by the Office of Science and Engineering Personnel, National Academy of Sciences. The most recent survey was completed in 1989 and covered individuals who received S/E doctorates between 1946 and 1988.

The data from the three surveys is used as the input material for the Science and Engineering Tabulating Model, which was developed for the NSF by Mathematica Policy Research, Inc. The primary function of the model is to integrate data from the Experienced Sample and Recent Science and Engineering Graduate surveys to produce national estimates of the magnitude and characteristics of the S/E population in

the United States. The results of the 1988 Recent Science and Engineering Graduate survey were integrated with forecasts of the characteristics of the Experienced population (the last survey of this population was conducted in 1986).

Forecasts generated were based on the assumption that the number of scientists or engineers in a specific field may be determined from historical trends. A regression model was developed that estimates S/E field numbers from

1. Current and past levels of research and development funding.
2. Current and past numbers of graduate students in S/E fields.
3. Current and past numbers of advanced educational degrees granted in S/E fields.
4. The general health of the national economy.

The NSF report does not specifically quantify the separate categories of programmer or systems analyst. However the general category of "Computer Specialties" is quantified. To be considered for quantification as an engineer or scientist, a person must meet at least two of the following criteria:

1. Has earned a degree in the natural sciences, social sciences, or engineering.
2. Has been employed in S/E occupation.
3. Has professionally identified as a scientist or engineer on the basis of total education and work experience.

To be considered as part of the computer specialties category a person must be considered as a computer scientist, computer systems analysts or "other" computer scientists.

Computer engineers are classified as engineers and computer programmers are specifically not included in the classification. Although programmers are excluded from the data and systems analysts are only one factor of the computer specialties, I surmise that this is the best quantification information available.

The supply of computer specialists employed in the computer field as based on the NSF report are presented in figure 1.

Year	Quantity	Percent Increase Over Previous Year
1976	119,000	Baseline Year
1978	177,000	48.7395%
1980	207,800	17.4013%
1982	299,000	43.8883%
1984	436,800	46.0869%
1986	562,600	28.8003%
1988	708,300	25.8976%

Figure 1.

As indicated in Figure 1, the number of computer specialists has seen an bi-annual growth rate ranging from a low of 17.4013% to a high of 48.7395% every two years since 1976. This translates to a 595.21% growth in the number of

computer specialists since 1976 or an annual average growth of 49.6%.(NSF 90-314, 1988, pp: v-7)

V. DATA ANALYSIS AND INTERPRETATION

In 1980 it was predicted that the supply of college graduates in computer profession would be no more than 157,000 during the period of 1978 to 1990. However, the number of computer professionals actual increased by more than 531,000 by the end of 1988. The same projection indicated that the number of jobs that would be opening in the industry would be some 550,000 during the same time period. Based on the rate at which the supply of computer professionals is growing, the supply of computer professionals has probably exceeded the projected demand and is many times greater than the original predicted supply.(Gillin, 1983, pp: 4)

Another author predicted that by 1985 there would be a 40% shortfall of programmers despite a predicted supply of over 300,000 programmers (Howard, 1980, pp: 1-4). In fact, by 1985 the supply of computer specialists was nearly 500,000, which outpaced the predicted supply by over 66%, which more than covered the predicted 40% shortfall.

Comparing the past predictions of growth in the supply of computer professionals and the actual growth recorded, it is apparent that the rate of growth in the supply of computer professionals has been underestimated. Additionally, the rate of growth in the computer specialist field appears to be very

healthy, having increased from 119,000 in 1976 to 708,300 in twelve years.

Having a quantification of the supply of computer professionals, one must look toward the demand side of the equation to be able to make an assumption about the existence of a shortage. We face the same difficulties in trying to quantify the demand for computer professionals that we faced in trying to quantify the supply.

In the literature, we find numerous references to "increased demand", but very few numbers are mentioned. In 1980, Dunhill, a professional recruiting company conducted a nationwide survey among the 20 top metro markets and revealed that companies across the board plan to increase their hiring in 1981 by anywhere from 10%-40% (Decamp, 1980, pp: 44-48). The difficulty with this type of quantification data is that it fails to indicate the overall demand, it only indicates the change in the demand that was planned, and does not address the question of the costs involved for the additional personnel.

In 1980 a prediction was made that jobs for computer professionals were expected to increase nearly 84% by 1990, more than four times the projected rate of growth for all occupations in the country at that time (Decamp, 1980, pp: 44-48). In reality, by 1988 jobs for computer professionals had increased by over 340%.

By 1981 the U.S. Department of Labor predicted a 109% increase in the number of computer professionals employed over the next decade (Decamp, 1980, pp: 44). Again, the estimates were significantly short of the market reality.

In 1981, employee demand figures were derived from surveys conducted by Fox-Morris Personnel Consultants and its National Personnel Consultants affiliates over the previous three years. The surveys indicated computer employee demand rates were 21.2% in 1979 and 18.7% in 1980.(Dooley, 1981, pp: 1-6) The question arises, 21.2% and 18.7% of what?

There is very little data available in the literature that attempts to quantify the demand for computer professionals, and I was unable to find any data that related the quantity of computer professionals demanded with the cost related to obtaining those personnel.

Unlike the quantification data available from the National Sciences Foundation's survey of science resources series, I have not been able to locate any type of quantification data for the aggregate demand for computer professionals.

VI. CONCLUSIONS AND RECOMMENDATIONS

A good estimate of the supply of computer specialists has been produced by the National Science Foundation. By comparing the results of NSF's bi-annual survey over time it is possible to get a clear and accurate projection of the supply of computer professionals and the growth rate of that supply. Although the National Science Foundation specifically excludes programmers from the classification of "computer specialists," it seems reasonable to assume that the supply of programmers is proportional to the supply of other computer specialists.

Although the demand for computer specialists is referred to in an abstract form in many publications, I have not been able to locate any evidence that a good estimate of demand for computer specialists exists. The quantity demanded for a given product or service can only be discussed when the price for the product or service is known, (the higher the price of the product, the lower the quantity demanded). The reference to the demand for computer specialists that does exist in the literature does not relate the quantity demanded to the prices (in this case, wage rates) involved. The only mention of wages in regards to computer professionals can be summarized as "they cost to much."

It is necessary to be able to quantify the demand for computer specialists in order to determine that the demand exceeds the supply and the existence of a computer specialist shortage exists. Without data on the demand of computer specialists, statements regarding a "shortage" are merely impressionistic.

I would opine that there is not a shortage of computer specialists in our market driven economy. Over the last ten years we have witnessed a tremendous increase in the supply of computer specialists. Likewise, we have witnessed perpetual complaints of the high wage rates of computer personnel/programmers and a "shortage" of these same personnel.

Information is an organizational resource, and like any other resource it has value and costs associated with it. When an organization makes the decision to invest in an information system, all costs, including the cost of computer specialists must be considered. Being a market driven economy, computer specialists are price seekers and charge for their services what they believe the buyers of their services are willing to pay. Organizations may complain about the high cost of computer programmers, but they must consider the value of a functioning information system worth the total cost of the system, including personnel costs or they would investigate alternatives to avoid the high costs.

Computer professionals services, like any resource are limited. We have witnessed an increase in the supply of those services over the last decade. The use of computer professional services is limited only by the imagination. So the classic economic problem emerges, limited resources with unlimited desire for the resource. What brings reality to the demand for resources is the costs associated with obtaining the resource. As the consumers of computer specialist services have bid up the price of those services, the demands for the services have come to an equilibrium with the available supply.

Perhaps when organizations come to view information systems as a limited resource, similar to capital, personnel, time and equipment, we will hear less about the "software crisis".

LIST OF REFERENCES

Anonymous, "Vendor's Software Musts: Function, Portability", Computer World, v15n21, 25 May 1981.

Batt, R., "AEA Working on Solutions to DPer Shortage", Computer World, v15n25, 22 June 1981.

Beeler, J., "Recruitment Held Critical Task for Managers," Computer World, v15n27, 6 July 1981.

Beeler, J., "Handicapped Easing Programming Shortage", Computer World, v15n15, 13 April 1981.

Bosworth, G.H., "Managing A Programmer Shortage", Datamation, v29n8, August 1983.

Cash, J.I., and others, Corporate Information Systems Management: Text and Cases, 2nd ed., Irwin, 1988.

Cook, R., "IBM's System Software Strategy for the 80's", Computer World, v15n43, 26 October 1981.

Couger, D.J., "Motivating Analysts and Programmers", Computer World, v24n3, 15 January 1990.

Decamp, D., "Employment: The '81 Outlook", Computer World, v15n1, 29 December 1980.

Dooley, A., "Survey Finds Demand for DPers up 15.9%", Computer World, v15n29, 20 July 1981.

Emmett, R., "Capacity Planning Pitfalls", Datamation, v28n13, December 1982.

Gillin, P., "Predictions of DPers Shortages Came True", Computer World, v17n12, 21 March 1983.

Howard, B., "TLC, Education Diet Urged for Programmers", Computer World, v14n51, 15 December 1980.

Howe, R.W., "Data Center Recruitment: An Image Problem?" Computer World, v16n8, 22 February 1982.

Johnson, B., "Analyst Hails '80s as Decade Users will Determine Shape of Information Systems", Computer World, v16n33, 16 August 1982.

Kitfield, J., "Is Software DOD's Achilles' Heel?", Military Forum, July 1989.

Lasden, M., "Is There Really A Programmer Shortage?", Computer Decisions, v14n7, July 1982.

Leigh, W.E., Burgess, C., Distributed Intelligence: Trade-Offs and Decisions for Computer Information Systems, South-Western, 1987.

MacDonald, A., "Visual Programming", Datamation, v28n11, October 1982.

Nasser, K., "Becoming an IS Mentor: Mentoring Can be the Best Policy", Computer World, v23n47, 20 November 1989.

National Science Foundation, Surveys of Science Resources Series NSF 87-322, "U.S. Scientists and Engineers: 1986", National Science Foundation, 1986.

National Science Foundation, Surveys of Science Resources Series NSF 90-314, "U.S. Scientists and Engineers: 1988", National Science Foundation, 1988.

Paznik, M.J., "Technical Temps-A Growing Trend", Administrative Management, v47n2, February 1986.

Pitagorsky, G., "Firms Can Act to End Programming Crunch", Computer World, v14n51, 15 December 1980.

Poe, R., "The Era of Packaged Software Dawns in Japan", Datamation, v33n24, 15 December 1987.

Raimondi, D., "VAX Boom Triggers Hiring War," Computer World, v20n48, 1 December 1986.

Ruhl, J., "Part-Time Jobs are Catching on", Computer World, v24n21, 21 May 1990.

Scannell, T., "Many DP Jobs Open, But It's a Buyer's Market (part 3)", Computer World, V16n38, 20 September 1982.

Shoor, R., "Software Litigation Trends", Computer World, v15n1, 29 December 1980.

Stibbens, S., "DP Careers: The Movement is Up, Up and Away", Infosystems, v27n12, December 1980.

Venkatakrishnan, V., "The Information Cycle", Datamation, v29n9, September 1983.

Verity, J.W., "Importing Software Talent", Datamation, v27n9, 25 August 1981.

Washington, F., "Only You can Prevent an MIS Shortage", Computer World, v22n2, PP: 11 January 1988.

Yasaki, E.K., "Body Shopping is Big Biz", Datamation, v27n9, 25 August 1981.

BIBLIOGRAPHY

Center for Naval Analysis, CRM 84-42 AD-B111 990, "Review of Department of Naval Civilian Career Management Program for ADP Personnel" by Naron, S.E., Hodgman, J.F., Thomason, J.E., pp: 5-14, August 1984.

Desmond, J., "Firm Charts Path to Efficiency", Computer World, V19n7, pp: 47-52, 18 February 1985.

Dudgeon, G., "Software Service Vendors Reduce Systems Programmer Grudgework", Data Management, v23n5, pp:43-47, May 1985.

Dyson, E., "Programmer Shortage is Actually a Software Gap", Computer Decisions, v13n11, pp: 72-75, November 1981.

ECONOMIC REPORT OF THE PRESIDENT, TRANSMITTED TO CONGRESS February 1990.

Johnson, B., "Software Makers Get Lesson in How to Sell it", Computer World, v15n13, pp:34-35, 30 March 1981.

Kirchner, J., "U.S. Won't Tinker with DP Shortage: Official", Computer World, v16n15, pp: 13, 12 April 1982.

Kirchner, J., "SSA's DP Staff Slammed for System Troubles", Computer World, v15n40, pp: 10-11, 5 October 1981.

Kornai, J., "Economics of Shortage", Volume A, North-Holland, 1980.

MacEnaney, M., "Fourth-Generation Tools Do Not Replace COBAL: IDC Study", Computer World, V19n4, pp: 39 28 January 1985.

National Defense University, National Security Essay Series 83-1, ADA131626, "Computer Science Training in the Department of Defense: The Silent Problem", by R.L. Hedges, pp: 27-36, 23 August 1983.

Pastore, R., "Staking Out Systems Integration", Computer World, V22n50, pp: 101, 12 December 1988.

Qureshi, T.N., "Attacking Software Crisis A Macro Approach", Master's Thesis, Naval Postgraduate School, Monterey, California, March 1985.

Santaella, E.M., and Slamecka, V., "Toward Native Language Software for Information Management", Information Processing & Management, v20n4, pp: 527-534, 1984.

Seaman, J., "Make or Buy...Software, Processing, Maintenance, and Facilities Management, Too", Computer Decisions, v12n12, pp: 42-56, December 1980.

Snyder, J., "Generators Overcome Programmer Shortages", Computer Decisions, v13n3, pp: 34-42, March 1981.

Snyder, J., "Greater Productivity, Not More Programmers", Computer Decisions, v13n8, pp:30-43, August 1981.

Snyder, J., "Snyders on the Software Highlights of 1980 and What They Mean for You", Computer Decisions, v12n12, pp: 74-87, December 1980.

Snyder, J., "What's Coming Down the Pike in Software", Computer Decisions, v13n12, pp: 123-140.
Sullivan-Trainor, M., "MIS Stares at Skills Crunch", Computer World, V22n10, pp: 1,117, 7 March 1988.

Software Engineering Institute Technical Report ESD-TR-86-214 SEI-86-TM-7, "The Challenges of Educating the Next Generation of Software Engineers", by Gibbs, N.E., and Ford, G.A., pp: 1-7, May 1986.

Vanski, J. E., "Projected Labor-Market Balance In Engineering And Computer Specialty Occupations: 1982-1987", Labor-Market Conditions for Engineers: Is There a Shortage? Proceedings of a Symposium, National Academy Press, 1984.

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